THE IMPORTANCE OF CONTINUOUS AND HOMOGENEOUS GASKET CONDUCTIVITY UP TO 40 GHz

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Abstract: Due to the impact of higher and higher frequencies, shielding gaskets at frequencies above 1 GHz are needed for the so called ‘in-cicuit’ and ‘on board’ shielding applications. In this paper, the importance of a continuous conductivity between all parts of an enclosure, and the homogeneous distribution of the conductivity in the frequency range up to 40 GHz are demonstrated, using a stripline methodology for characterising the Shielding Effectiveness (SE) of conductive gaskets.

Keywords: conductive gaskets, shielding

1. INTRODUCTION

Due to the impact of higher and higher frequencies, the SE characterisation of shielding gaskets at frequencies above 1 GHz is needed for in-circuit and on board shielding applications. These types of shielding are applications where noisy components must be shielded, in order to cause no interference with the environment (intersystem EMC) or with adjacent electronic components (intrasystem EMC). It must be noted that wireless communication systems are not only moving into very high frequencies, but are operated at low transmitting power, requiring a very clean and low noise floor for errorless reception.
A typical example as occurring practice is shown in figure 1.

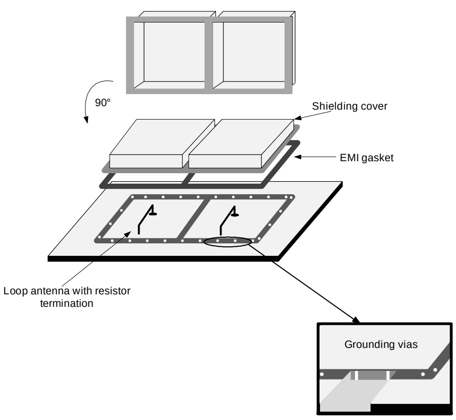

Figure 1. Typical configuration of on board shielding

The quality of shielding strongly depends not only on the way conductive contact is made from the small enclosure (CAN) to the ground plane of the PCB, or in between compartments of enclosures with separate parts, but also on the homogeneous distribution of the conductive contacts over the complete circumference.

In an earlier papers [2]–[5], a method was proposed for the frequency range up to 40 GHz. In this paper, the method is used to demonstrate the importance of a continuous and homogeneous gasket conductivity up to 40 GHz.

2. STRIPLINE METHOD

The stripline measuring setup is shown in the next figures 2 - 4. It has an overall size of 17x20 cm.
A stripline has been designed to fit a characteristic impedance of 50 Ohm (red arrow). The width of the stripline is 12 cm and the height above the solid GND copper plate is 2.6 cm. The active length of the stripline is 9 cm, and both tapering sections are 3 cm each.

The inner side of the stripline is covered with an absorbing ferrite sheet, to avoid too much influence of the short tapering. SMA connectors are mounted through the solid GND plate.

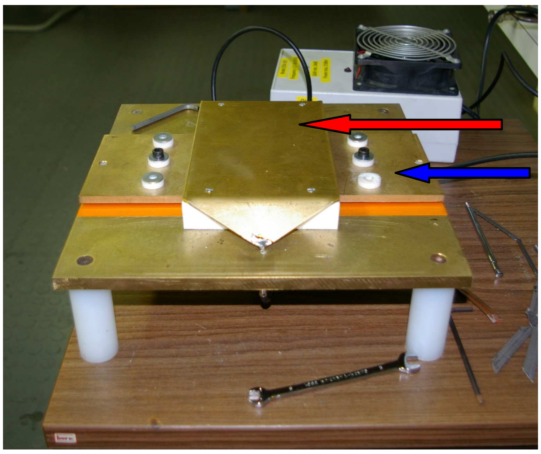

Figure 2. Overall view of the stripline setup

Another solid copper plate is intended to hold the gasket, and is inserted in the open area of the stripline (blue arrow).

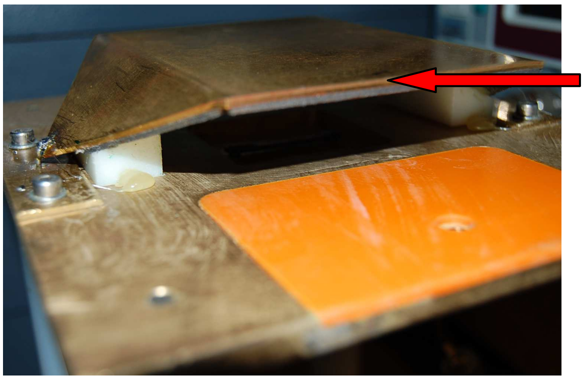

Figure 3. Detailed view of the stripline setup

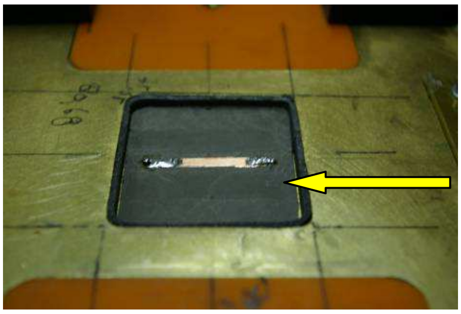

Figure 4. General view of base-plate and embedded µstrip

A µstrip is embedded in the GND plate and surrounded by absorbing material, in order to reduce the resonant effects of this “virtual” embedded enclosure. The realisation is shown in figure 4. The µstrip simulates a trace on a PCB.
The µstrip has a length of 4 cm and is made on an appropriate substrate of microwave PCB material, and is embedded in a 5x5 cm opening.

Both µstrip and stripline are terminated in a 50 Ohm resistive load at one end. The other ends are the transmitter and receiver part of the set up.

By covering the embedded µstrip with a plate or sheet (blue arrow in figure 2), the Shielding Effectiveness (SE) of this material can be evaluated, by performing two measurements: a first one as the coupling between µstrip and stripline in an open structure and a second one with the sample.

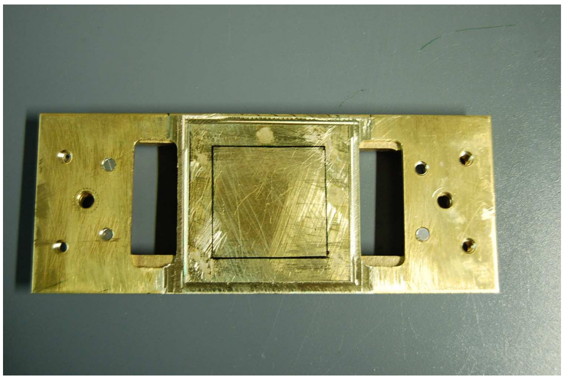

Figure 5. Solid copper plate acting as gasket sample holder

Using a solid copper plate to cover the embedded µstrip, and inserting a gasket in between this plate and the solid GND plate of the stripline structure, the SE of the gasket can be measured.
In this way, the copper plate can act as a gasket sample holder, and the gasket may be carefully positioned on this solid plate. This is shown in figure 5.

3. REFERENCE MEASUREMENT OF A GASKET

In order to enhance the dynamic range of the structure, a wideband 1 Watt amplifier is used to inject the signals into the measuring system.
Using this amplifier, the open structure coupling has an average of -15 dB down to - 30 dB over the whole frequency range of 1 upto 40 GHz. This is shown in the next figure 6. This results in a dynamic range of more than 100 dB at 1 GHz and still 80 dB at 40 GHz.

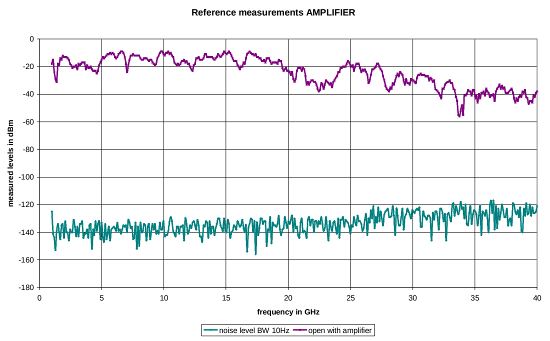

Figure 6. Open coupling and noise floor

In the next figure 7, the Shielding Effectiveness (SE) of a reference gasket is given.

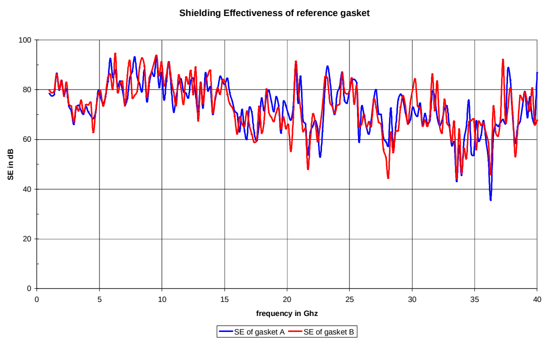

Figure 7. SE of the reference gasket

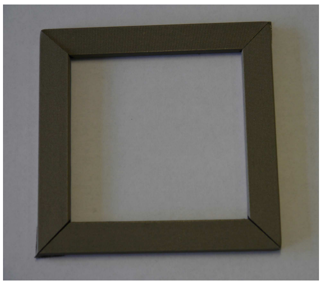

Figure 8. Picture of the gasket structure

4. IMPORTANCE OF CONTINUOUS CONDUCTIVITY

In this section, the importance of a continuous conductivity that must be maintained over the complete structure of gasket and enclosure (in this case: gasket holder/gasket/GND plate), is reported from measurements.
As a first test, a paper sheet has been inserted between the gasket and the GND plate, insulating the gasket completely from this GND plate.

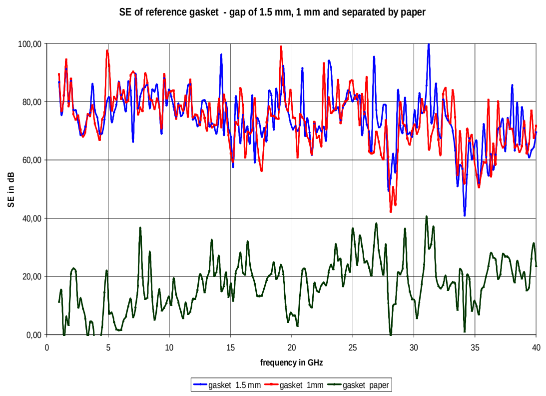

Figure 9. Influence on SE by inserting a paper sheet

A second test has been performed by insulating only one branch of the gasket square. The effect on the observed and measured SE is shown in figure 10, where the insulated branch has been positioned perpendicularly and parallel with the µ strip/stripline structure. No clear influence of this difference in physical position bould be observed.

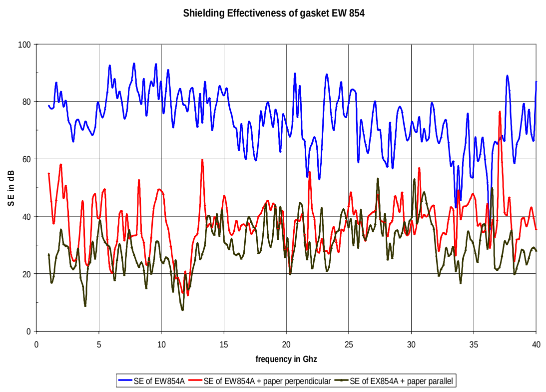

Figure 10. SE of the reference gasket, with only one branch of the gasket structure insulated by a paper sheet

The practical implication of this fact is observed when gasket structures are diecutted, loosing (partially) the continuous conductive connection between upper and lower part of the gasket.
An example of a diecutted gasket is shown in figure 11, as indicated by the blue arrows. Only two of the external edges are maintaining the conductive contact between the flat surfaces.

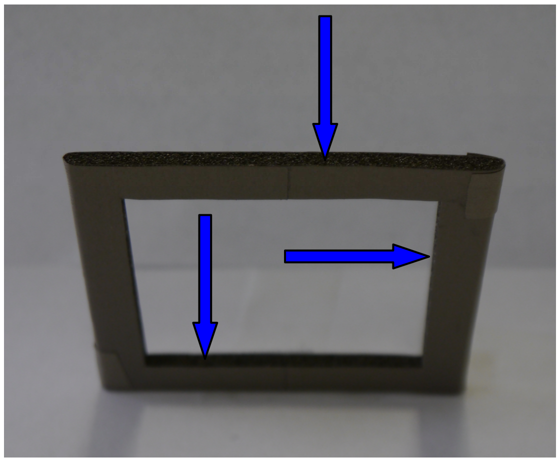

Figure 11. Blue arrows indicate the diecutted sections

The effect of the loss of continuous conductivity between both flat surfaces of the gasket are illustrated in the next graph (fig. 12). Both reference gasket (see fig. 8) and the diecutted gasket (see fig. 11) are made from the same foam and the same fabric wrapped around.

In fig. 12, the blue graph shows the SE of the reference gasket, the red graph is the one of the diecutted version and the green one is the SE obtained when covering the external diecutted edges by a conductive tape (the 4 internal edges remaining diecutted, giving a non-conductive edge).

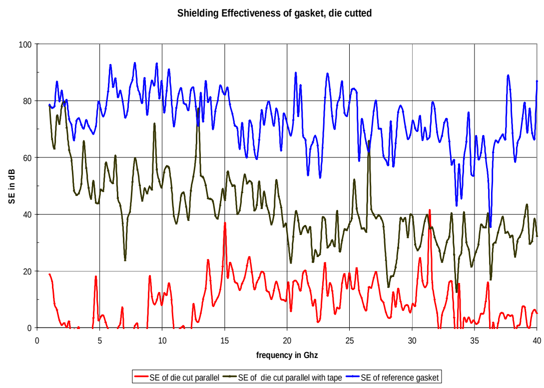

Figure 12. SE of a diecutted gasket with a non-conductive foam

By introducing a conductive internal foam, a type of continuous conductivity between the flat surfaces of the gasket is maintained.

The obtained SE is directly depending on the conductivity of this foam, and the conductivity of the contacting surface between the externale fabric and the foam.

The effect of the use of a conductive foam on the SE of a diecutted gasket is given in fig. 13 and is clearly observed when comparing with the measured SE of the same kind of gasket with a non-conductive foam, as given by the red graph in the fig. 12 above.

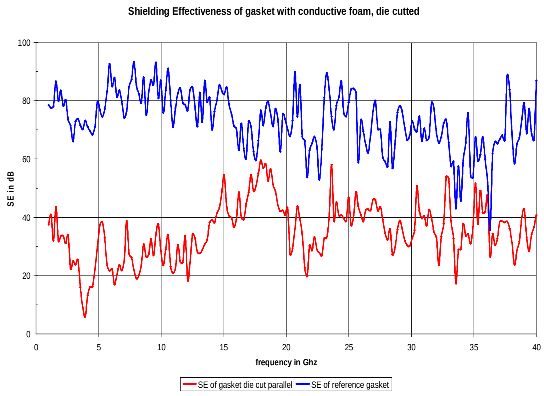

Figure 13. SE of diecutted gasket with conductive foam

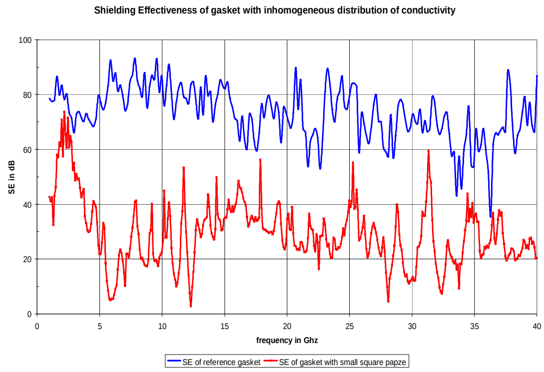

Figure 15. SE of gasket with a small square of paper sheet inserted

5. IMPORTANCE OF A HOMOGENEOUS DISTRIBUTION OF THE CONDUCTIVITY

Another question concerns the effect of an inhomogeneous distribution of the conductivity over the surfaces of a gasket. In section 4, this effect was already mentioned, when insulating only one branch of the gasket structure used for this study. The question remains when smaller discontinuities might occur.
Two examples of these phenomena are illustrated in figure 14.

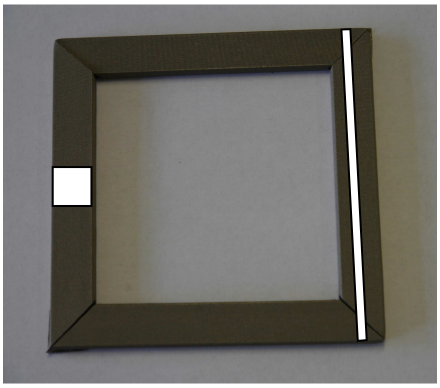

Figure 14. Two examples of a non-homogeneous distribution of the gasket surface conductivity

A small square of paper sheet has been inserted, simulating a gap in the structure (left). A small strip has been inserted, simulating the use of a non-conductive glue or other effects (right).

The resulting SE values for the case of the small square are given in fig. 15 and for the small strip are given in fig. 16.
For both cases, a decrease of the resulting SE is clearly observed, which illustrates the importance of a homogeneous distribution of the conductivity of the contacting surfaces between the enclosure parts and the gasket applied.

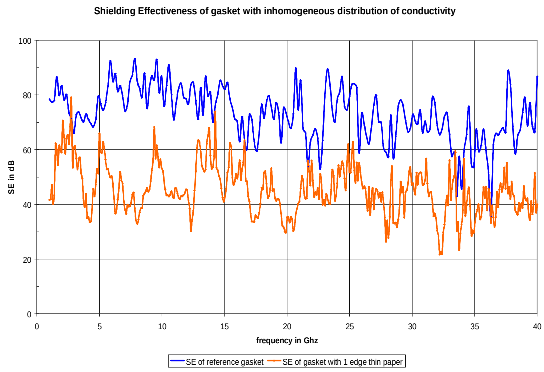

Figure 16. SE of gasket with a thin strip of paper sheet inserted

A practical example where both phenomena occur in a combined way is a compressed finger stock gasket. Following its construction, there are a set of small gaps over the surfaces. But also by compressing, a non-contacting area (as a small strip over the finger stock) is also occuring. This is illustrated in the next figure.

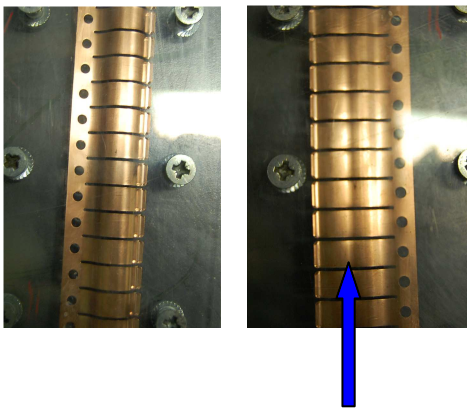

Figure 17. Compression of a finger stock gasket

The blue arrow at the right part of figure 17 indicates the "gap" occuring during compression of a finger stock gasket, altering the homogeneous distribution of the surface conductivity of the gasket.

The effect on the SE behaviour of a CuBe finger stock gasket is given in figure 18.

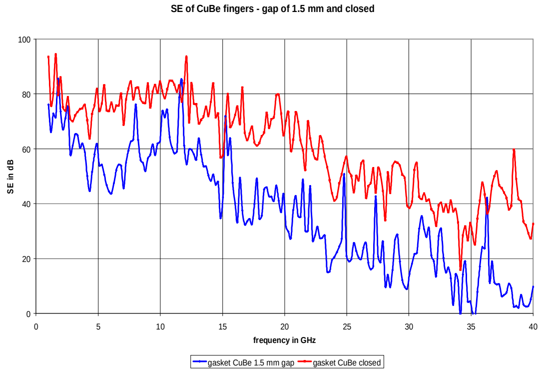

Figure 18. SE of compressed CuBe gasket

CONCLUSION

In this paper, the importance of continuous and a homogeneous distribution of the conductivity of gaskets has been shown by an empirical study and illustrated by measurements, up to the frequency range of 40 GHz.

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